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Frequent Binge Drinking After Combat-Acquired Traumatic Brain Injury Among Active Duty Military Personnel With a Past Year Combat Deployment

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Objective: To determine whether combat-acquired traumatic brain injury (TBI) is associated with postdeployment frequent binge drinking among a random sample of active duty military personnel. **Participants:** Active duty military personnel who returned home within the past year from deployment to a combat theater of operations and completed a survey health assessment ($N = 7155$). **Methods:** Cross-sectional observational study with multivariate analysis of responses to the 2008 Department of Defense Survey of Health Related Behaviors Among Active Duty Military Personnel, an anonymous, random, population-based assessment of the armed forces. **Main Measures:** Frequent binge drinking: 5 or more drinks on the same occasion, at least once per week, in the past 30 days. TBI-AC: self-reported altered consciousness only; loss of consciousness (LOC) of less than 1 minute (TBI-LOC <1); and LOC of 1 minute or greater (TBI-LOC 1+) after combat injury event exposure. **Results:** Of active duty military personnel who had a past year combat deployment, 25.6% were frequent binge drinkers and 13.9% reported experiencing a TBI on the deployment, primarily TBI-AC (7.5%). In regression models adjusting for demographics and positive screen for posttraumatic stress disorder, active duty military personnel with TBI had increased odds of frequent binge drinking compared with those with no injury exposure or without TBI: TBI-AC (adjusted odds ratio, 1.48; 95% confidence interval, 1.18-1.84); TBI-LOC 1+ (adjusted odds ratio, 1.67; 95% confidence interval, 1.00-2.79). **Conclusions:** Traumatic brain injury was significantly associated with past month frequent binge drinking after controlling for posttraumatic stress disorder, combat exposure, and other covariates. **Key words:** *binge drinking*, *combat*, *deployment*, *military personnel*, *posttraumatic stress disorder*, *traumatic brain injury*

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UNHEALTHY ALCOHOL USE is common and persistent among military personnel returning from the conflicts in Iraq and Afghanistan, with a consistent association of deployment and combat exposure to unhealthy alcohol use.[1–9] One-third of military personnel in 2008 reported drinking at or above hazardous drinking levels, including 5% who met screening criteria for possible alcohol dependence.[10] These trends are even more apparent among younger enlisted military personnel.[11,12] Annual prevalence of monthly binge

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14. ABSTRACT

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drinking (≥5 drinks on 1 occasion for men, ≥4 drinks for women) among military personnel and their civilian counterparts who were 21- to 25-year-olds was 60% versus 46% and among 17- to 20-year-olds was 44% versus 33%.[11,13] A recent study comparing drinking behaviors of male military personnel with those of civilians found that both the number of combat traumas and positive screens for probable posttraumatic stress disorder (PTSD) or depression were associated with increased frequency of binge drinking among male military personnel.[9]

Binge drinking is associated with numerous negative consequences for both civilians and military personnel: alcohol-impaired driving,[1,13–15] criminal violations,[13,16] and military-specific job performance problems,[13,17] all of which limit the ability of the Department of Defense (DOD) to promote the force readiness of its troops.[1,13,18,19] A recent analysis of the 2008 DOD Health Related Behaviors Among Active Duty Military Personnel Survey (HRB Survey) found that frequent binge drinkers (defined in that report as those who binge drink at least once a week in the past month) reported almost 3 times the rate of alcohol-related serious consequences and more than twice the rate of alcohol-related productivity loss than moderate/heavy drinkers.[17] Thus, military personnel who reported frequent binge drinking had more negative alcohol-related outcomes from their drinking than another group of more infrequent unhealthy drinkers. This study did not examine the impact of deployment or combat exposure in relation to drinking behaviors or drinking-related consequences or productivity loss.

Combat-acquired traumatic brain injury (TBI) is frequently found among military personnel who have served in OEF/OIF.[20–22] Unique to military personnel, combat-acquired TBI is commonly caused by a blast or explosion, prompting an alteration of consciousness or brief loss of consciousness (LOC), most often resulting in a mild TBI.[20,21,23–27] While most civilians who experience a mild TBI undergo a restorative brain process within the first few months after injury, a small minority experience ongoing residual effects.[28] Military personnel with combat-acquired TBI may experience persistent physical and psychological symptoms, particularly because combat-acquired TBIs are often accompanied by other physical and emotional trauma associated with combat exposure.[29]

Studies of civilian populations suggest that drinking alcohol after experiencing a TBI may be problematic[30–32]; however, research on alcohol use after combat-acquired TBI is just beginning.[33] Some civilians who experience a TBI decrease their alcohol use following injury,[34] whereas others may increase their alcohol use.[35] Furthermore, a recent study of more than 4000 UK military personnel returning from Operation Enduring Freedom or Operation Iraqi Freedom (OEF/OIF) found that those who experienced a mild TBI were 2.3 times more likely to report alcohol misuse than those without a TBI.[36] Another study examined the medical records of more than 3000 US military personnel who deployed to (OEF/OIF) in Afghanistan and Iraq from 2004 to 2007 and were treated for blast-induced injuries. Blast-injury patients with a mild TBI had a slightly higher unadjusted rate of alcohol use disorders than those without a TBI (6% vs 4.9%); however, the rates were not statistically significant in multivariate analyses.[37] A third study using Veterans Administration administrative health records found that OEF/OIF veterans with a positive TBI screen were twice as likely to have alcohol- or drug-related diagnoses compared with OEF/OIF veterans without a TBI.[22]

Nevertheless, what we know from military studies is limited because the studies have been based on those seeking health services, rather than population-based studies, or have been limited to postdeployment assessment where personnel may be reluctant to divulge injury information as they prepare to transition home from deployment. Research designed to identify factors that contribute to unhealthy drinking is a crucial topic with implications for the health and readiness of the US military, as we know that military personnel have high rates of excessive binge drinking, placing them at higher risk for alcohol-related health and social consequences and other negative effects on the military readiness of the armed forces.[13,19,38] The present study is the first to use a population-based survey to assess the association of self-reported, combat-acquired TBI with postdeployment frequent binge drinking among US active duty military personnel who returned from a combat deployment within the past year. Given prior findings,[22,35–37] we hypothesize that military personnel with a self-reported combat-related TBI* would be more likely to be frequent binge drinkers. This study is a significant contribution to what is currently known, as we control for other characteristics of military personnel, including combat exposure and symptoms of PTSD or depression, factors that may confound the association of drinking behaviors and TBI.

METHODS

Data source

The 2008 HRB Survey is an anonymous, population-based assessment of the active duty component of the US military under a contract for the TRICARE Management Activity (TMA) and the US Coast Guard.[1] The

*We define TBI based on self-report elicited by the HRB Survey method. It does not represent a clinical diagnosis or an observed event.

instrument includes numerous items related to drinking behaviors and their consequences as well as measures of deployment history, combat exposure, demographics, and mental health issues. While the 2008 HRB Survey is the 10th in a series of surveys sponsored by the DOD since 1980, it is the first in its history to include the TBI screening questions. These items are similar to those used by the DOD in its postdeployment health assessments.[39]

The survey was administered anonymously to 28 546 active duty personnel from all service branches. To capture the worldwide distribution of the US armed forces, a dual-mode administration was used. The primary data collection method was group administration at military installations, with mailed surveys used at smaller locations. Using multiple stages, a random sample of personnel was selected with military installations as the first-stage units and then random selection of 12 strata formed by gender and pay-grade combinations. The survey was administered between May and June 2008, took an hour to complete, and had an overall response rate of 71.6%. Details of the sampling design, multilevel sampling frame, and data collection methods have been published elsewhere.[1]

Study sample

To examine our research question, we selected from all HRB respondents those who reported returning from a combat deployment in the past 12 months. This selection allowed us to identify those with a recent combat-acquired TBI and then to examine postdeployment drinking behaviors soon after return from the deployment. Of the 28 546 military personnel who completed the 2008 HRB Survey, 7169 (25.1%) met the criterion of a combat deployment in the past 12 months; 14 were excluded because they did not complete items regarding drinking status, for a final study sample of 7155. Figure 1 describes the respondents included in this sample.

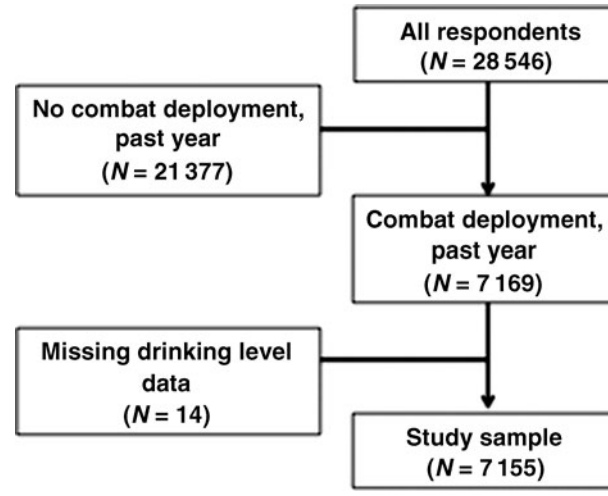

Figure 1. Selection of active duty military personnel study sample.

Measures

Dependent variable

The dependent variable was frequent binge drinking, which was assessed on the questionnaire by asking military personnel on how many of the past 30 days did they drink 5 or more drinks on the same occasion (≥4 for women); 1 or more days was defined as binge drinking. *Frequent binge drinking* was defined as a minimum of weekly binge drinking episodes during the month, also referred to as heavy drinking in some literature.[38,40] The other group includes nondrinkers, those who drink but do not binge, and those who binge but do not meet the requirement for frequent binge drinking. Prior research has shown that frequent binge drinking, compared with less frequent binging and unhealthy drinking behaviors other than binging, is associated with increased alcohol-related serious consequences and productivity loss among male military personnel.[17]

Key independent variable: TBI

The key independent variable is self-reported, combat-acquired TBI during the last deployment. Traumatic brain injury was defined with 3 subgroups: (1) those reporting altered consciousness but no actual loss of consciousness (TBI-AC); (2) those reporting loss of consciousness of less than 1 minute (TBI-LOC <1); and (3) those reporting a LOC of 1 minute or greater (TBI-LOC 1+). The classification for self-reported TBI was based on responses to 2 item sets. Both item sets asked only about the respondent's most recent deployment and therefore did not assess possible TBIs that may have occurred on prior deployments or over a lifetime. The first item set asked respondents whether they had experienced a blast or explosion, vehicle accident, a fragment or bullet wound above the shoulders, a fall, or other injury event during their last deployment. From these items, we defined 2 mechanisms of potential injury event exposures: (1) blast/explosion exposure and (2) other injury etiologies. The second item set assessed possible symptoms that may be associated with the injury event, including length of LOC or being "knocked out" (<1, 1-20, or >20 minutes), being "'dazed, confused, or saw stars" (altered consciousness), or not remembering an injury event (altered consciousness). The questionnaire does not require that the respondent assess whether or not his or her symptoms are the result of a particular injury.

Responses to these 2 items allowed us to construct, among those with an injury event, a 3-level ordinal variable to reflect the intensity of TBI. While guided by

the Ohio State University TBI Identification Method, we had insufficient information to map these levels accurately.[41] The current questionnaire permits reporting of multiple symptoms but does not allow distinctions between 1 or more than 1 injury events. We coded type of symptoms on the basis of this hierarchy: TBI-LOC 1+, TBI-LOC <1, TBI-AC when multiple symptoms were reported. Because of small sample size, we collapsed those with an LOC of 1 to 20 minutes and those with an LOC of greater than 20 minutes into 1 response category (TBI-LOC 1+). The HRB Survey symptom response groups permit recoding LOC as up to 20 minutes and greater than 20 minutes. This provides insufficient information to code LOC using the American Congress of Rehabilitation Medicine's definition of mild TBI, which has a cutoff of under 30 minutes.[25] Eighty-nine respondents reported an LOC of greater than 20 minutes of which an unknown number may have had a moderate or severe TBI. The reference group in our analysis is composed of those with no exposure to an injury event and those with exposure but no self-reported TBI symptoms.

Comorbidity

We constructed several comorbidity measures on the basis of responses about recent symptoms. Posttraumatic stress disorder was assessed using the PTSD Checklist–Civilian Version, which consists of 17 symptoms present in the past 30 days, from trauma events during military or nonmilitary experiences, based on the diagnostic definition of PTSD. The standard diagnostic cutoff score of 50 or greater was used to classify a positive screen for current PTSD.[42,43] Depression was assessed with the Version A Burnam depression screen that included 1 item from the Center for Epidemiological Studies Depression Scale and 2 items from the Diagnostic Interview Schedule.[10,44,45] A positive screen for past year depression was coded if the respondent reported symptoms for more than 2 weeks in the past year or reported 2 or more lifetime years of feeling depressed "much of the time" and reported feeling depressed at least 1 day in the past week. Suicidal ideation was assessed as present if a respondent reported seriously considering suicide in the past year.

Lifetime combat exposure

Lifetime combat exposure was assessed with 17 questions about different combat experiences such as handling dead bodies or witnessing members of a unit being killed. Respondents reported the number of times they experienced each of the 17 items encompassing all previous deployments. We classified respondents on the basis of their summary score value as *none* (0), *moderate* (1-9), and *high* (10+) combat exposure levels.[10,46]

Covariates

Demographic variables considered in the analysis were sex, and dummy variables for age category (17-20, 21-25, 26-34, and 35+), service branch (Army, Navy, Marine Corps, Air Force, and Coast Guard), race/ethnicity (white/non-Hispanic, black/non-Hispanic, Hispanic, other), marital status (never married, married/living as married, divorced/separated, and widowed), education level (high school or less, some college, and college graduate), and pay grade (junior enlisted and non-commissioned officer/E1-E6, senior non-commissioned officer/E7-E9, warrant officer/W1-W5, officer/O1-O10).

Analysis

All analyses were weighted to account for the complex sampling design of the HRB Survey. Frequencies were calculated for 2 groups, frequent binge drinkers and "others" inclusive of drinkers and nondrinkers, along with design-based F tests to assess significance levels of the bivariate relationships. Multivariate logistic regression on frequent binge drinking was used to estimate unadjusted odds ratios (ORs) associated with the combat-acquired TBI subgroup (model 1). Model 2 added possible risk factors for frequent binge drinking (demographics and lifetime combat exposure) to estimate the adjusted odds ratios (AORs) associated with the TBI subgroups. We excluded age group from these models because of its multicollinearity with pay grade and opted to include pay grade instead of age because it is military specific and often included in studies of military populations. Model 3 added various measures for comorbidity to the adjusted model, model 3A added PTSD, and model 3B added depression and suicidal ideation. Both PTSD and depression were not included in the same model because of their high interrelationship. The sample sizes for specific multivariate models varied because of nonresponse to some of the covariates. We conducted a post hoc sensitivity analysis on the multivariate models to determine whether the TBI-LOC 1+ results were being driven by the 89 cases where LOC was greater than 20 minutes - cases that may include those with moderate or severe TBIs.

All analyses were conducted in STATA 10,[47] using survey (svy) and subpopulation (subpop) commands to take into account response weights.

The HRB Survey was conducted with approval by the DOD/TMA and RTI International institutional review boards. The de-identified data set analyzed here was released by the DOD/TMA privacy office upon

determination that the study was exempt by both TMA's Human Research Protection Program and Brandeis University's Committee for Protection of Human Subjects.

RESULTS

Table 1 shows the distributions of characteristics of the study population in 2 drinking groups, frequent binge and others (including no drinking). The overall sample is composed of mostly males (89.0%), those who identified as white/non-Hispanic (63.1%), married personnel (61.7%), those with some college education (46.2%), with an average age of 28.6 years (data not shown). The majority of the sample is enlisted personnel (85.9%), with at least 2 deployments since September 11, 2001 (55.3%), with moderate or heavy combat exposure (73.7%), with the greatest representation from the Army (37.3%) and Navy (27.2%). Almost a quarter of the overall sample reported past year depression, 13.4% had a positive PTSD screen in the past month, and 5.0% reported suicidal ideation in the past year.

More than a quarter (25.6%) of those on a combat deployment in the past year reported frequent binge

TABLE 1 *Characteristics of active duty military personnel returning from a past year combat deployment, by frequent binge drinking (N = 7155) weighted percentages*[a]

	Total study sample (*N* = 7155; 100%)	Frequent binge drinkers (*n* = 1597; 25.6%)	Other[b] (*n* = 5558; 74.4%)	Design-based *F* Test, *P*-value
Sex				≤.0001
Male	5754 (89.0%)	1420 (94.1%)	4334 (87.2%)	
Age, y				≤.001
17-20	366 (7.5%)	100 (9.2%)	266 (6.9%)	
21-25	2386 (36.9%)	794 (52.2%)	1592 (31.7%)	
26-34	2459 (33.3%)	483 (27.9%)	1976 (35.2%)	
≥35	1944 (22.3%)	220 (10.7%)	1724 (26.3)	
Service branch				≤.0001
Army	1571 (37.3%)	418 (44.3%)	1153 (34.9%)	
Navy	2067 (27.2%)	442 (24.0%)	1625 (28.2%)	
Marine Corps	1478 (13.2%)	388 (16.2)	1090 (12.1%)	
Air Force	1835 (21.8%)	294 (14.8%)	1541 (24.1%)	
Coast Guard	204 (0.6%)	55 (0.6%)	149 (0.6%)	
Race/ethnicity				≤.0001
White, non-Hispanic	4240 (63.1%)	1012 (68.9%)	3228 (61.1%)	
Black, non-Hispanic	1189 (17.4%)	199 (12.4%)	990 (19.2%)	
Hispanic	1056 (11.0%)	262 (11.9%)	794 (10.7%)	
Other, non-Hispanic	670 (8.4%)	124 (6.8%)	546 (9.0%)	
Marital status				≤.0001
Married/living as married	4487 (61.7%)	768 (48.2%)	3719 (66.4%)	
Divorced/separated	742 (9.6%)	197 (11.4%)	545 (9.0%)	
Never married	1888 (28.6%)	615 (40.1%)	1273 (24.6%)	
Widowed	14 (0.1%)	7 (0.3%)	7 (0.1%)	
Education				≤.0001
High school or less	2163 (34.7%)	738 (50.5%)	1425 (29.2%)	
Some college	3364 (46.2%)	685 (40.2%)	2679 (48.3%)	
College graduate	1628 (19.1%)	174 (9.3%)	1454 (22.5%)	
Pay grade				≤.0001
E1-E3	798 (9.5%)	285 (14.2%)	513 (7.9%)	
E4-E6	4159 (66.1%)	1051 (73.3%)	3108 (63.5%)	
E7-E9	873 (10.3%)	121 (5.9%)	752 (11.8%)	
W1-W5	193 (1.1%)	26 (0.6%)	167 (1.3%)	
O1-O3	694 (8.3%)	85 (4.5%)	609 (9.6%)	
O4-O10	438 (4.7%)	29 (1.5%)	409 (5.8%)	
Combat deployments since September 11, 2001				NS
1	3042 (44.6%)	691 (46.9%)	2351 (43.9%)	
2	1923 (27.2%)	428 (27.0%)	1495 (27.3%)	
≥3	2048 (28.1%)	443 (26.1%)	1605 (28.8%)	

(*continues*)

TABLE 1 *Characteristics of active duty military personnel returning from a past year combat deployment, by frequent binge drinking (N = 7155) weighted percentages*[a] *(*Continued*)*

	Total study sample (*N* = 7155; 100%)	Frequent binge drinkers (*n* = 1597; 25.6%)	Other[b] (*n* = 5558; 74.4%)	Design-based *F* Test, *P*-value
Lifetime combat exposure[c]				≤.0001
None	1989 (26.3%)	377 (21.3%)	1612 (28.0%)	
Moderate	2569 (33.7%)	459 (26.0%)	2110 (36.3%)	
High	2263 (40.0%)	667 (52.6%)	1596 (35.7%)	
Mental health problems (Yes/No)				
PTSD positive screen, past month[d]	839 (13.4%)	350 (24.6%)	489 (9.6%)	≤.0001
Positive depression screen, past year[e]	1482 (22.3%)	482 (32.1%)	1000 (19.0%)	≤.0001
Suicidal ideation, past year	325 (5.0%)	124 (8.5%)	201 (3.8%)	≤.0001

Abbreviations: NS, nonsignificant; PTSD, posttraumatic stress disorder.

[a]Weighted percentages are shown to display policy-relevant findings. The table shows unweighted numbers. The weighted number for the study sample is 393 884, with 87 915 frequent binge drinkers and 305 969 nonfrequent binge drinkers. Some participants did not answer all relevant questions.

[b]The "other" comparison group includes nondrinkers, those who drink but do not binge, and those who binge but do not meet requirement for frequent binge drinking.

[c]Lifetime combat exposure was measured by assessing the number of times military personnel were exposed to 17 experiences including exposure to incoming fire, mines, improvised explosive devises, viewing/handling dead bodies, firing on the enemy, suffering unit casualties, or being wounded in combat.

[d]PTSD was measured with the PTSD Checklist—Civilian Version, which consists of 17 items about the past 30 days, using the standard diagnostic cutoff score of 50 or greater.

[e]Depression was measured with the Version A Burnam depression screen that included 1 item from the Center for Epidemiological Studies Depression Scale and 2 items from the Diagnostic Interview Schedule. Military personnel were identified as needing further evaluation or assessment for depression if they reported symptoms for more than 2 weeks in the past year or reported 2+ lifetime years of feeling depressed "much of the time" and felt depressed at least 1 day in the past week.

drinking. Compared with those who do not binge drink on a weekly basis, frequent binge drinkers were more likely to be men, to be in the youngest age range (17-25 years), white, single (never married or divorced/separated), and have a high school education or less. In terms of military characteristics, frequent binge drinkers compared with others were more likely to be in the Army or Marine Corps, have a junior (E1-E6) pay grade, and have high lifetime combat exposure. In terms of clinical characteristics, frequent binge drinkers were more likely than others to have a positive screen for current PTSD, past year depression, and report suicidal ideation in the past year.

Among the study sample, 39.3% reported being exposed to at least 1 injury event on the most recent combat deployment. These events were postcoded as a blast/explosion, "other" injury etiology (eg, vehicular accident/crash, fragment or bullet wound above the shoulders, fall), or both blast and other event (see Table 2). Most common was the report of experiencing both a blast and other injury etiology (19.8%) during the most recent combat deployment, with similar proportions experiencing blast only (9.7%) or other injury etiologies only (9.8%). In total, almost one-third (29.5%) of the study sample had experienced a blast. We could not determine whether personnel experienced 1 or more injury events.

Overall, 13.9% of the study population reported experiencing a TBI after an injury exposure during their most recent deployment. The most common type of TBI was TBI-AC (7.5%), followed by TBI-LOC <1 (3.5%), and TBI-LOC 1+ (2.8%). Proportions at each TBI level varied by the type of injury event exposure (see Table 2). The highest rate of self-reported TBI (49.3%) was among those personnel who experienced both a blast and other injury etiology. Those with a blast exposure only reported the lowest rate of each TBI level. Almost 15% of men reported a TBI, whereas only 4.9% of women did so (data not shown). There was a dose-response relation between both TBI and PTSD and TBI and depression. For example, the relation between TBI and PTSD revealed that among those with TBI-AC, 26.8% had a

TABLE 2 *TBI and injury event exposures in past year combat deployment sample (N = 7155), weighted percentages and population estimates*[a,b,c]

Injury event exposure	Sample, *n* (%, population estimates)	Self-report TBI level of those with exposure: No TBI	Altered consciousness	LOC <1 min	LOC 1+ min	Total of exposure group
Blast/explosion exposure only	653 (9.7, 35 948)	567 (83.0%)	57 (11.9%)	21 (3.6%)	8 (1.5%)	100%
Other injury etiologies only[d]	740 (9.8, 40 737)	562 (75.2%)	109 (14.2%)	41 (6.0%)	28 (4.7%)	100%
Blast/explosion and other injury etiologies[d]	1 107 (19.8, 60 941)	613 (50.7%)	257 (25.1%)	124 (12.9%)	113 (11.3%)	100%
Subtotal with exposure (%, population estimates)	2 500 (39.4, 137 625)	*n* = 1 742 (86.1%, 95 897)	*n* = 423 (7.5%, 23 286)	*n* = 186 (3.5%, 10 239)	*n* = 149 (2.8%, 8 202)	100%
No exposure	4 655 (60.6, 256 259)[e]					
Total population estimate	7 155 (100, 393 884)					

Abbreviations: LOC, loss of consciousness; TBI, traumatic brain injury; min, minutes.
[a]The table shows unweighted numbers and weighted percentages. Sums may not add to 100% because of rounding.
[b]Results were significant at the $P \leq .0001$ level. The *P* value was calculated with the use of a design-based *F* test.
[c]Population estimates for a subpopulation of active duty military personnel returning from a combat deployment in the past year (population $N = 393\,884$).
[d]Vehicular accident/crash, fragments wound above the shoulders, bullet wound above the shoulders, falls, and "other" self-reported events.
[e]Three hundred ninety-six military personnel in the sample had missing injury event data. These missing data were imputed to become zeros (rather than missing data), which decreases the weighted percentages of those with TBI slightly.

positive PTSD screen, 41.5% of those with TBI-LOC <1 reported PTSD, and 59.7% of those with TBI-LOC 1+ had a positive PTSD screen (data not shown).

Table 3 presents the unadjusted and adjusted association of TBI with the probability of frequent binge drinking. Unadjusted analyses showed that military personnel with a TBI were significantly more likely to report frequent binge drinking in the past month than those without a TBI. As TBI severity increased, the odds of frequent binge drinking also increased in a dose-response relation. Model 2 showed that when controlling for demographic characteristics and combat exposure, the AORs for each TBI level decreased slightly but remained significant.

In all 3 adjusted models, several demographic and combat exposure variables were significantly associated with frequent binge drinking. Men had higher odds of frequent binge drinking than women. Those in the Air Force had lower odds of frequent binge drinking than those in the Army, but those in the other branches were not significantly different from those in the Army. Military personnel who identified as black or "other" race/ethnicity had lower odds of frequent binge drinking than white personnel. Those married or living as married had lower odds of frequent binge drinking than those who had never been married. Military personnel at the E7-E9 pay grade, warrant officers, and commissioned officers all had lower odds of frequent binge drinking than those at the lowest pay grades (E1-E6). And, those with high lifetime combat exposure had higher odds of frequent binge drinking than those with no lifetime combat exposure.

In model 3a, a positive screen for PTSD had a significant association with frequent binge drinking, yet 2 levels of combat-acquired TBI remained significantly associated as well. Those with a TBI-AC had increased odds of frequent binge drinking, as did TBI-LOC 1+. In model 3B, both a positive depression screen and suicidal ideation in the past year were significantly associated with frequent binge drinking; however, once again, TBI-AC and TBI-LOC 1+ remained significantly associated with frequent binge drinking, although the AORs were attenuated and smaller than observed when PTSD was the covariate.

When we conducted sensitivity analyses after dropping 89 cases with an LOC of greater than 20 minutes, the coefficient for those with TBI-LOC 1+ was only slightly smaller (AOR, 1.25; 95% CI, 0.69-2.27) and was not statistically significant ($P = .45$), which may be related to a substantially smaller TBI-LOC 1+ group (data not shown).

DISCUSSION

There are significant costs of frequent binge drinking among returning active duty military personnel. Drinking at unhealthy levels may interfere with reintegration and complicate other combat-related injuries and

TABLE 3 *Multiple regression models: Unadjusted and adjusted odds ratios for combat-acquired TBI level and frequent binge drinking (N = 7155)*[a]

	Proportion of frequent binge drinking[b] of those with TBI			
		Adjusted OR (95% CI)		
	Unadjusted OR (95% CI), Model 1	Model 2: adjusted for demographics and combat exposure	Model 3A: adjusted for demographics, combat exposure, and PTSD	Model 3B: adjusted for demographics, combat exposure, depression, and suicidal ideation
TBI level				
None (ref.)	1.0	1.0	1.0	1.0
Altered consciousness	2.25 (1.80-2.80)[c]	1.61 (1.29-2.01)[c]	1.48 (1.18-1.84)[c]	1.58 (1.27-1.95)[c]
LOC <1 min	2.45 (1.80-3.32)[c]	1.48 (1.01-2.17)[d]	1.18 (0.77-1.80)	1.37 (0.93-2.02)
LOC 1+ min	3.72 (2.45-5.66)[c]	2.30 (1.40-3.75)[c]	1.67 (1.00-2.79)[d]	1.97 (1.17-3.29)[d]
Gender				
Female (ref.)		1.0	1.0	1.0
Male		2.15 (1.83-2.53)[c]	2.24 (1.90-2.64)[c]	2.17 (1.85-2.55)[c]
Service branch				
Army (ref.)		1.0	1.0	1.0
Navy		.98 (0.76-1.28)	.97 (0.75-1.25)	.94 (0.73-1.20)
Marine Corps		1.04 (0.82-1.31)	1.01 (0.79-1.28)	1.01 (0.80-1.27)
Air Force		0.67 (0.50-0.90)[e]	0.70 (0.52-0.94)[d]	0.69 (0.51-0.94)[d]
Coast Guard		0.96 (0.62-1.47)	0.96 (0.63-1.48)	0.98 (0.64-1.50)
Race/ethnicity				
White, non-Hispanic (ref.)		1.0	1.0	1.0
Black, non-Hispanic		0.59 (0.51-0.69)[c]	0.60 (0.51-0.70)[c]	0.58 (0.50-0.67)[c]
Hispanic		0.87 (0.75-10.01)	0.86 (0.74-1.00)	0.82 (0.70-0.97)[d]
Other		0.66 (0.53-0.82)[c]	0.64 (0.51-0.80)[c]	0.61 (0.49-0.77)[c]
Marital status				
Never married (ref.)		1.0	1.0	1.0
Married/living as married		0.49 (0.41-0.59)[c]	0.49 (0.42-0.58)[c]	0.50 (0.42-0.59)[c]
Divorced/separated		0.89 (0.72-1.08)	0.90 (0.73-1.09)	0.87 (0.72-1.06)
Widowed		2.64 (0.76-9.12)	2.17 (0.69-6.80)	2.16 (0.76-6.10)
Pay grade				
E1-E6 (ref.)		1.0	1.0	1.0
E7-E9		0.50 (0.39-0.64)[c]	0.53 (0.42-0.68)[c]	0.52 (0.41-0.67)[c]
W1-W5		0.38 (0.16-0.91)[d]	0.41 (0.18-0.95)[d]	0.41 (0.18-0.97)[d]
O1-O10		0.39 (0.29-0.52)[c]	0.42 (0.31-0.56)[c]	0.42 (0.31-0.56)[c]
Lifetime combat exposure				
None (ref.)		1.0	1.0	1.0
Moderate		0.93 (0.75-1.14)	0.93 (0.75-1.15)	0.89 (0.72-1.10)
High		1.41 (1.11-1.78)[e]	1.31 (1.03-1.68)[d]	1.32 (1.03-1.69)[d]
PTSD positive screen, past month			2.22 (1.84-2.67)[c]	
Positive depression screen, past year				1.53 (1.30-1.81)[c]
Suicidal ideation, past year				1.65 (1.07-2.56)[d]

Abbreviations: CI, confidence interval; E, enlisted; LOC, loss of consciousness; O, officer; OR, odds ratio; ref., reference group; TBI, traumatic brain injury; W, warrant officer.

[a]Some participants did not complete all relevant questions.

[b]Frequent binge drinking is defined as binge drinking (drinking ≥5 drinks on 1 occasion for men or ≥4 for women) at least weekly in the past 30 days).

[c]Results were significant at the $P \leq .001$ level. The P value was calculated with the use of a design-based F test.

[d]Results were significant at the $P \leq .05$ level.

[e]Results were significant at the $P \leq .01$ level.

conditions. More than a quarter (25.6%) of military personnel who had been on a combat deployment in the past year reported frequent binge drinking, placing themselves at very high risk of negative drinking consequences such as poor job performance and alcohol-impaired driving,[13,19] which may compromise their readiness for a subsequent deployment. Multivariate analyses indicated that those personnel with a TBI during their most recent combat deployment were more likely to be frequent binge drinkers than those without TBI, controlling for demographics, lifetime combat exposure, and comorbidity. Although we cannot draw causal inferences from this cross-sectional analysis, our findings suggest that experiencing a TBI is one driver of unhealthy drinking postdeployment.

Military personnel with a positive PTSD screen had higher odds of frequent binge drinking than those without a positive screen. The findings also suggest that PTSD may partially mediate the relation between TBI and frequent binge drinking. When PTSD was added, the AORs for all TBI level variables decreased from model 2. Although reduced in magnitude, TBI-AC and TBI-LOC 1+ remained significant. Thus, TBI has an apparent independent relation to frequent binge drinking.

Importantly, this study also demonstrates that TBI-AC increased the likelihood of frequent binge drinking in all models. The dose-response relation between TBI and frequent binge drinking apparent in the unadjusted model 1 was not as evident in models 2 and 3. However, the most severe TBI (TBI-LOC 1+) retained the highest AOR in all models. We can only speculate at this time about the diminution in dose-response relation of TBI level and frequent binge drinking in models 2 and 3. It may be an artifact of sample size, or more severe injury may be protective because of unknown mediating factors (eg, more likely to be on a prescription medication for symptom relief; more likely to have been advised not to drink to excess). There was also confounding of TBI level and positive PTSD screen, and the TBI-AC participants had the lowest proportion of positive PTSD screens. Finally, improved measurement of type of injury, particularly among those exposed to blasts, may provide additional, useful information about the nature of the TBI. Future studies could examine whether there are other injury characteristics associated with drinking behavior.

Almost 40% of the sample reported at least 1 injury event exposure during the deployment that ended in the past year, and 13.9% reported symptoms of TBI while on this recent deployment. This overall prevalence is within the range of estimates from previous US studies, which have reported a rate from 12% to almost 23%.[20–22,26,48–50] Unlike other studies that focused on a single branch, often the Army,[21,26,50] this study included active duty personnel from all branches, and TBI exposure varied greatly by branch. In this population-based study, TBI prevalence on the most recent deployment was more than 24% of Army personnel, followed by the Marine Corps (18.9%) and Coast Guard (9.6%), with the lowest TBI prevalence in the Navy (4.8%) and Air Force (4.7%) (data not shown).

Limitations

We cannot draw causal inferences from a cross-sectional design. As with most studies of combat-acquired TBI, we relied on self-report measures of TBI symptoms rather than a clinical determination of TBI immediately after an injury event. In addition, we did not know lifetime history of TBI from prior deployments, non–combat-related exposures, or multiple injury exposures.[28,51] The presence of prior TBIs may interfere with military personnel's ability to process the combat exposure or deployment in general and indirectly influence frequent binge drinking behavior. Furthermore, the survey did not ask precise questions about drinking behavior prior to deployment, so we did not know whether drinking behavior changed for any respondents and, if so, for which groups. Furthermore, by including only 2 groups in our analyses, in which the "other" group included those with less frequent binge drinking, as well as light drinkers and nondrinkers, the risks of less frequent binge drinking were not considered. To some degree, these unknowns would add to measurement error in our models, yet we found a significant relation between TBI and frequent binge drinking despite these possibilities.

Reflecting the HRB Survey question wording on "experiences," we did not know important details about the nature of blast or other injury events. Effects of a blast, for example, could vary widely on the basis of distance, enclosure, surroundings, postinjury actions, and other injuries in addition to the blast. We did not have any head injury severity measures. The HRB Survey instrument asked military personnel whether they had "experienced" the events (blast/explosion etc) but did not ask explicitly whether they had been "injured" by these events.

As previously noted, the most severe response category was "an LOC of greater than 20 minutes," which did not allow us to isolate those with a moderate or severe TBI from those with a mild TBI.[25] Because of the small sample size, we collapsed those with an LOC of 1 to 20 minutes and those with an LOC of greater than 20 minutes into 1 response category. It is possible that those with moderate or severe TBI could skew the findings for TBI-LOC 1+. However, this is not likely for several reasons. Most military personnel with moderate or severe head injury would be medically evacuated and some would not return to their permanent duty station.

Within 1 year, some may still be in medical or rehabilitation facilities, medically separated from the military, or otherwise not eligible to participate in the survey. While the cutoff points for LOC did not follow traditional definitions, a sensitivity analysis conducted post hoc revealed minimal changes in the pattern of findings, and explanatory power showed a slight advantage for the groupings we used.

Significance

This is the first study to use a population-based assessment of the active duty component of the armed forces to assess the association of combat-acquired TBI and frequent binge drinking in those returning from a combat deployment in the past year. This study is comprehensive in that it is worldwide, covers all branches of the active duty military, and was administered with the same dual-mode administration method throughout. Unlike previous studies that used convenience samples[21,22,26,37] and were restricted to 1 service branch,[4,21,26,50] this study has the unique ability to estimate prevalence for the armed forces as a whole. Our population estimates are that among 393 884 active duty military personnel with a past year combat deployment, 87 915 personnel engaged in frequent binge drinking. Furthermore, 137 625 personnel were exposed to at least 1 injury event, and 41 727 reported symptoms consistent with a combat-acquired TBI, the majority with altered consciousness (n = 23 286), and 18 441 military personnel with LOC. The finding that TBI-AC was associated with frequent binge drinking suggests that the armed forces and health care providers should not ignore mild TBI when considering whether returning military personnel are at risk for postdeployment consequences.

This study had other methodological strengths. Although, the HRB Survey is cross sectional in design, we chose respondents with a recent combat deployment. Thus, the outcome of interest, frequent binge drinking in the past 30 days, occurred after the deployment but in close proximity to the injury and TBI event, strengthening our ability to draw conclusions. Limiting our sample to those with a deployment in the past year may also have reduced recall bias relating to injury events and TBI. Also, since the HRB Survey was administered anonymously, respondents had nothing to lose by disclosing sensitive behavioral health information, such as drinking behaviors and comorbidities.[52] Similarly, there were no incentives to overreport combat-related injuries or behavioral health conditions, such as TBI or PTSD, as no medical benefits or job performance assessments were linked to the anonymous survey.

Implications

We outline implications of this study for clinical practice, public health interventions, and future research directions. Our findings highlight the importance of routine postdeployment screening for both TBI and PTSD and suggest that the presence of either or both of these conditions could trigger targeted alcohol assessment and brief counseling for those with unhealthy drinking behaviors, other brief interventions for those with frequent binge drinking, and referral to treatment for those with alcohol use dependence. Conversely, among those currently experiencing alcohol use problems, these findings suggest careful assessment of underlying TBI and PTSD comorbidities to understand whether and how these might be contributing to alcohol behaviors. Screening and brief interventions, particularly those done in primary care settings, have been effective in identifying those with problem drinking and helping these individuals reduce drinking and change unhealthy drinking patterns.[53–58] Furthermore, when deployed military personnel have been exposed to a potentially brain-injuring event such as a blast, the military could provide additional alcohol education and alcohol brief counseling designed to encourage them to rethink their drinking behaviors.[33] Current evidence suggests that these interventions may be most effective when offered by trained medical personnel in health care settings.

More research is needed that captures data on TBI-inducing combat events at the time of the injury. Surveys of injury events and TBI symptoms should be worded in ways that are consistent with clinical literature. Specifically, we recommend that future versions of the HRB Survey be strengthened by altering the response categories for severity of TBI to be able to isolate those with a mild TBI from those with moderate or severe injuries. In addition, respondents who report having been exposed to an "injury event" on a deployment could be prompted to report the types of injuries that resulted from the exposure event.

In sum, more research is needed to explore how TBI is related to postdeployment drinking behaviors. This study cannot answer the question whether TBI causes the increased likelihood of frequent binge drinking among active duty military personnel. It is unclear whether the change in the dose-response relation between TBI and drinking that occurred when mental health covariates were accounted for was due to an interaction among the variables or instead was due to sample size, measurement error, or some other artifact. More studies are warranted to explore these relations.

CONCLUSION

This study suggests that experiencing a combat-acquired TBI, even mild TBI with altered consciousness only, is associated with frequent binge drinking after deployment. In addition to being contraindicated for TBI patients, this level of unhealthy drinking interferes with

postdeployment reintegration and complicates healing from other combat-related injuries and conditions such as PTSD. The DOD may improve the health and well-being of military personnel by mounting evidence-based screening and brief interventions for unhealthy drinking in primary care and other medical settings for postdeployment military personnel with self-report of possible TBI events.

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